Oculomatic user guide

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https://github.com/oculomatic/oculomatic-release

1. Hardware requirements

   The minimum hardware requirements are a camera, lens, power, IR light, DAQ output cards, some BNC cables and a fast computer. I will go into detail on each component in the following paragraph.

   Oculomatic uses Point Grey Research machine vision cameras and has been successfully tested using two different camera options but other options are certainly possible (as long as they are ptgrey cameras and supported under the flycapture 2 SDK).

   A. Flea3 USB3 FL3-U3-13S2M-CS (max 240 FPS) 500$
   B. Flea3 USB3 FL3-U3-13Y3M-C (max 600 FPS) 600$

   My general recommendation is to go with option B or to switch to a Chameleon3 CM3-U3-13Y3M-CS (ca. 600 FPS) for 350 $. The Chameleon3 will work right away but is slightly bigger and comes in a plastic package instead of the nice Flea3 aluminum housing.

   The next thing you will need is a lens. This is a tough one and everything really depends on your setup. Lets get two things out of the way that get a lot of people confused. C-Mount lenses can be mounted on CS mount cameras (with a spacer) BUT CS-Mount lenses can NEVER be mounted on C mount cameras. There you have it: Always buy C-mount lenses if you can.
   Also make sure that the camera

   Additionally, you will need a USB3 cable that has mounting screws. Let me recommend the 5 meter point grey cables (ACC-01-2301) that are very well made and extremely affordable (15$). Since USB3 can not carry the voltage requirements for the camera at such length you will also need a power cable. For Flea3 cameras those are Hirose 25 8-Pin GPIO cables that need to be supplied with 12v. Either make one yourself by ordering a Hirose 25 connector from DigiKey or buy the entire kit with power supply directly from point grey (ACC-01-9009).
   For Chameleon3 cameras you need a 9 pin JST connector for power (ACC-01-3013). Chameon3 cameras also do not ship with a mounting bracket so depending on how you are planning to mount the camera it would be wise to purchase one directly as well.

For your IR illumination needs you can pretty much use anything that suites your need. We have had good success with super cheap lights from amazon (http://www.amazon.com/dp/B0067S8IZ8/ref=sr_ph?ie=UTF8&qid=1452021016&sr=1&keywords=IR). Make sure you rip out the photo diode to have no light fluctuations during your experiments and you are ready to go. Remember good homogenous illumination are key to getting a good tracking result !!!!!!!
For mounting camera as well as IR light we use manfrotto 244 magic arms attached to superclamps. Those things are pricey but any lab should have unlimited supply of these mechanical wonders.

For analog output you will need a national instruments DAQ card compatible with the current nidaqmx driver suite. The card needs to have at least 2 analog outputs (12bits or higher). We use old integrated PCI cards with self built breakouts (to reduce cable and breakout costs) but I can highly recommend newer cheap USB-6001 modules. USB vs PCI does not increase latency dramatically (maybe 100 microseconds) as of our testing and comes with the benefit of having direct breakout access as well as much lower cost. Hack together some BNC cables and off you go.

2. Software requirements

   Software requirements are simple:
   Install the latest windows 64 bit flycapture2.x.x SDK from the point grey website and add all executables during installation. Select USB3 (not the pro setting) during installation as your driver.
   Install the latest nidaqmx drivers from national instruments website.
   Install visual studio 2013 and 2015 redistributable c++ packages for your windows distribution.

   Unpack the oculomatic app anywhere you like and keep the folder /data in it's subdirectory. /data contains an XML file that encompasses all your settings. I plan on adding a selection of multiple "participant" settings files in the near future.

3. Setup

   Once you have everything installed and setup, we should try to see that your camera is really running. Open the FlyCaptureGUI program that was installed and select your connected camera.

   Do you see your camera in the selection dialog ?
   Yes -> Great double Click it and make sure you get an image on the next dialog
   No -> Don't worry yet: Make sure the USB3 connection is attached to the REAR of your PC into a direct mainboard USB3 port and NOT on the front or top of

your computer. Did that solve your problem ? If not disconnect power and USB and cycle through all the back ports until the camera is successfully found. WARNING: Even if your front USB3 panel appears to correctly identify the camera you can have stability issues later! Always connect to the Intel Chipset USB3 ports and never to any third part ports.

4. General user guide

The first step to your camera setup is always through the FlyCap2 control software. Most commands were initially integrated into Oculomatic, but keeping track of constant updates by PointGrey is cumbersome and unnecessary since these settings do not need to be changed once eye tracking is underway.

The FlyCap2 control software lets you choose your camera interface (figure 1). If for some reason you can not see your camera in the menu you should reset it manually by cycling the power to the camera as well as the USB connection (keep in mind both connections deliver power).

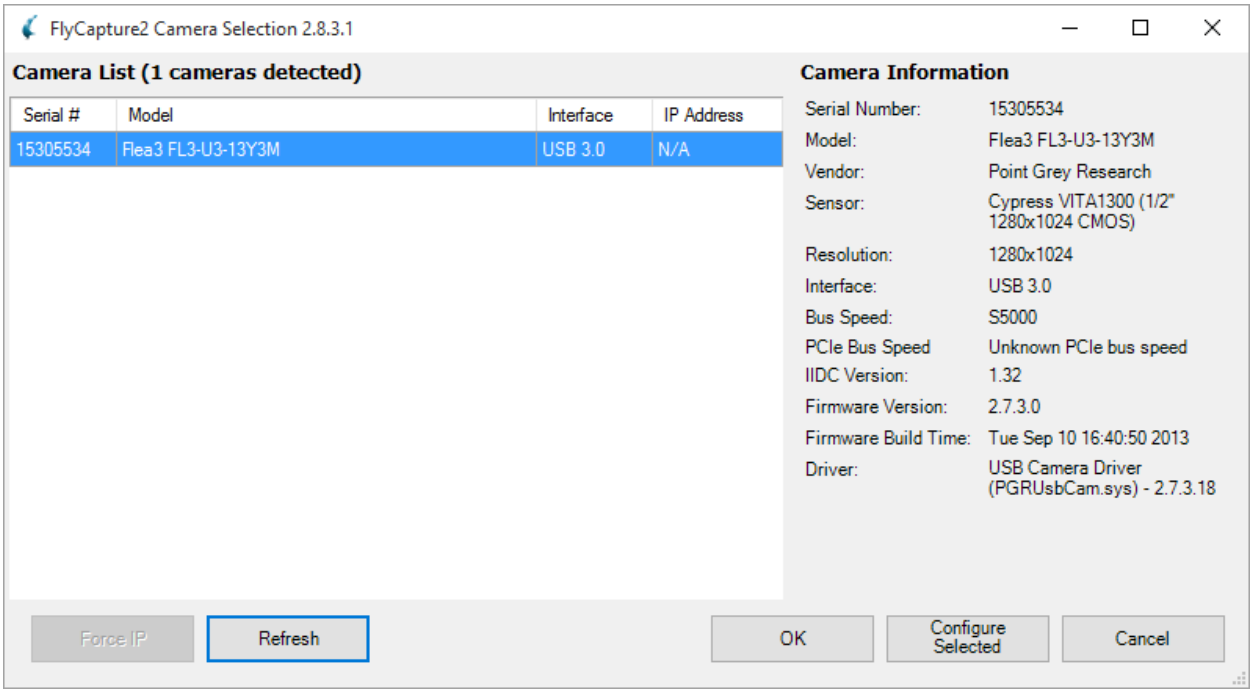

Figure 1. FlyCapture 2 Camera selection Interface.

Next you will be greeted by the main Camera overview screen (figure 2) which can tell you some important diagnostic information about the camera. On the left side you can see frame rates (don't worry if you don't see the FPS you expect here yet and do not worry if this number is not stable for now as Oculomatic will handle these calls internally later). In the same pane, the diagnostics information can be important. If you look at figure 2 you can see that

there are two red highlighted lines. Skipped frames shows you the number of skipped frames since negotiation of the USB connection. Link recovery count shows you the renegotiations since initialization. While you are looking at this data, it should NEVER increase. It is fine to have some skipped frames when initializing. It is also fine if some Link failures occurred (USB is a strange protocol) but it should remain stable and not increase.

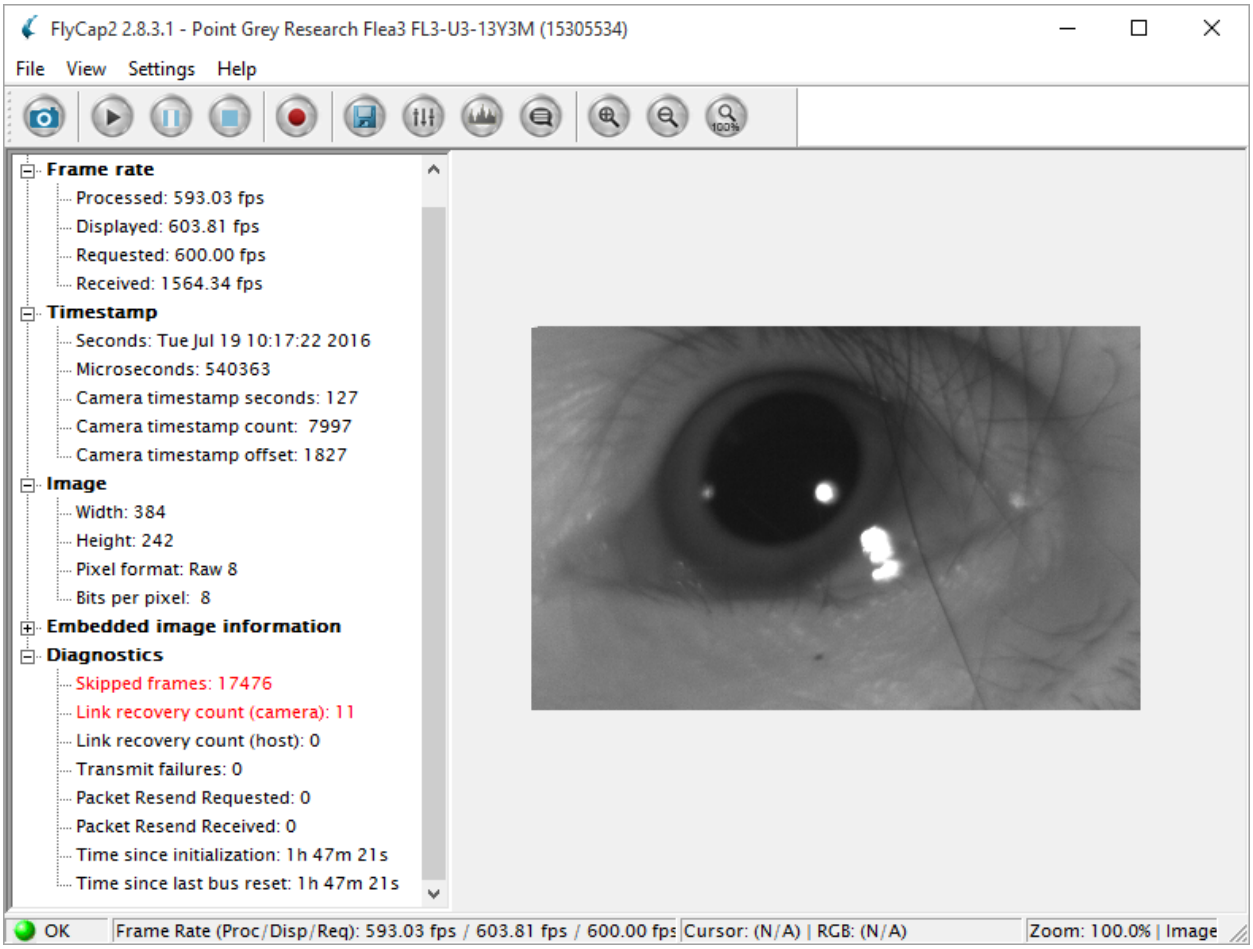

Figure 2. FlyCapture2 main camera control interface.

The next step is to go into the settings menu to do an initial setup of the camera save it to the camera register and get things calibrated. Figure 3 shows the main settings dialog of the FlyCapture 2 software.
Two important settings have to be set here: A. remove the auto flag from each of the settings except for the frame rate (Oculomatic will handle that later). You will likely play around with these settings later to get a nice clean and well illuminated image later. Important settings are Brightness and Exposure as well as Shutter and Gain. Those are the options you have to increase the overall exposure of the image without increasing the IR-LED brightness. For now, set these settings close to what you see in Figure 3 and move on.

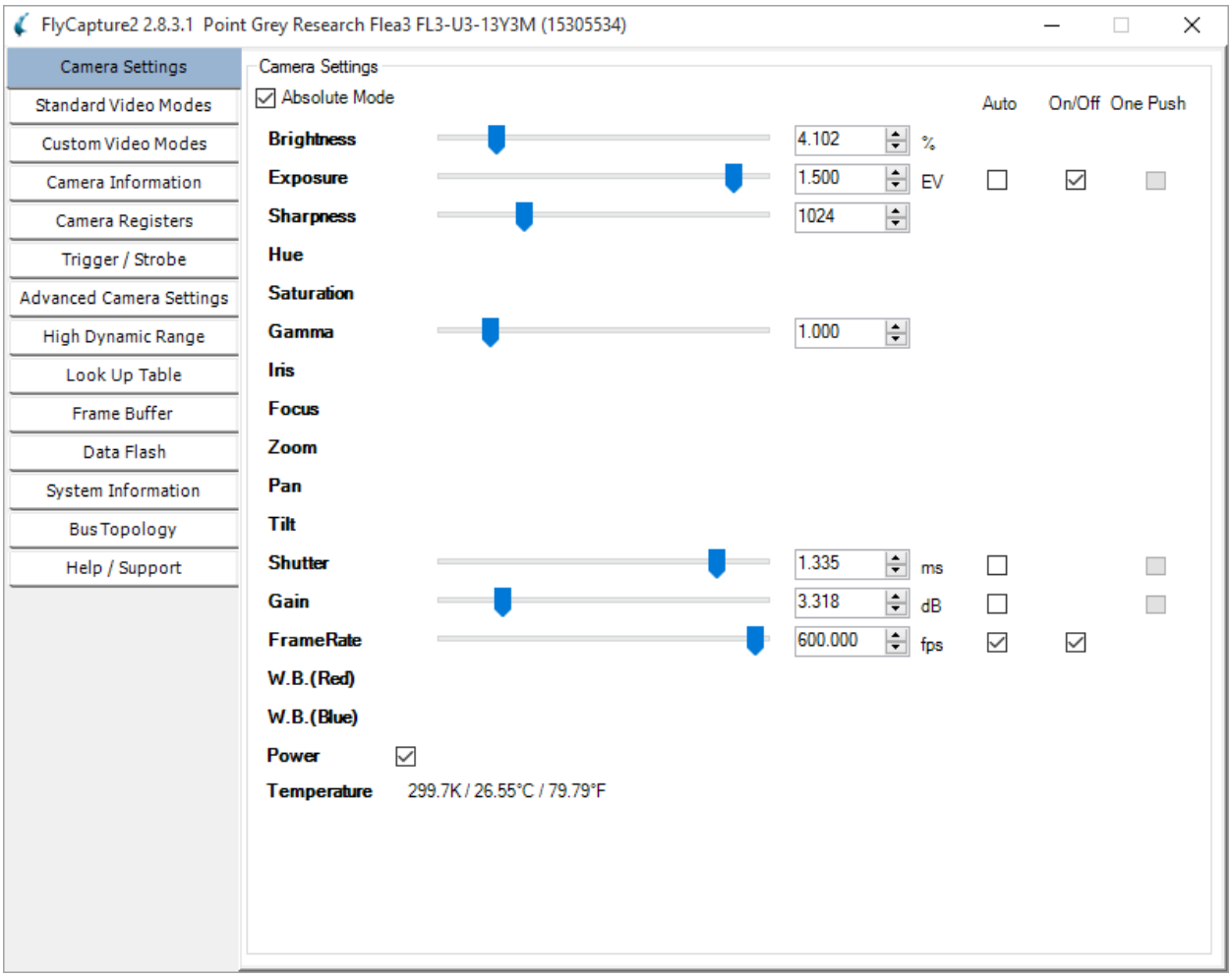

Figure 3. FlyCapture2 main settings control interface: Camera Settings

Next you need to change to the Custom Video Modes tab which you will likely revisit before each experiment.

In your first round of initial setup change the imaging mode to 0 if you are using the FL3-U3-13Y3M-C or other PointGrey Python1300 based sensor. Next change the Pixel Format to Raw 8 (let Oculomatic to the lifting of image conversion) and change the Image Width and height to 384x242. Make sure that the Packet Size Slider is at its maximum location and that the Packet delay is at 0. Click center ROI and apply the settings. Now your camera should be running at 600 FPS. If it is not go back to the main settings dialog and see where the FrameRate slider.

This is just needed during initial setup. You can save these settings by going into the Advanced Camera Settings (figure 5) and saving to one of the two available memory banks. When you restart the camera it should automatically load the last saved memory bank.

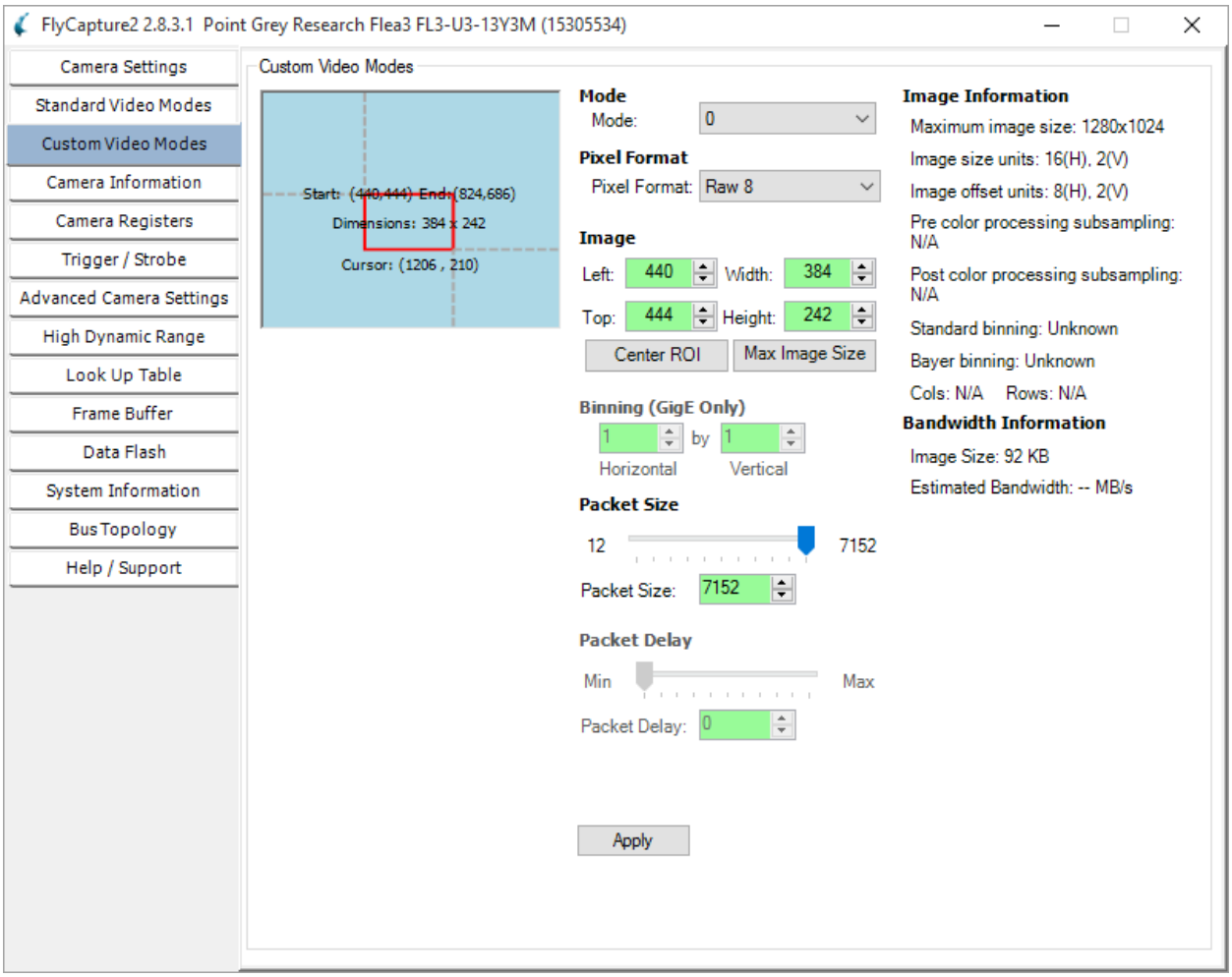

Figure 4. FlyCapture2: Custom Video Modes

You are now ready to setup your first ‘eye’ for tracking. Place the camera with IR and lens in such a way that you get a sharp well illuminated eye within the preconfigured FOV. It can require a little bit of trial and error. Make sure the shutter of your lens is fully open (lock it in place). Once you have your initial position (with a head fixed NHP for example) set up you can make fine tuning adjustments within the Custom Video Modes tab by shifting your field of view up and down or left and right. This gives you some degrees of freedom and rids your of the burden to readjust the camera on a daily basis. We assume that the subjects are fixed in the Z-Plane (distance from camera) but have slight daily offsets in X and Y.
During daily initial setup you just can just jump into this tab, bring the eye into a central location of the FOV as shown in figure 2 and start recording.

When you are done with setup close FlyCapture2 and open Oculomatic.
You are greeted by your subjects eye (figure 5) and a simple menu. The FPS counter should reflect your selected frame rate from the FlyCapture2 software

and should not vary by more than 1fps. The counter is supposed to help you in identifying possible communication problems with the USB controller.

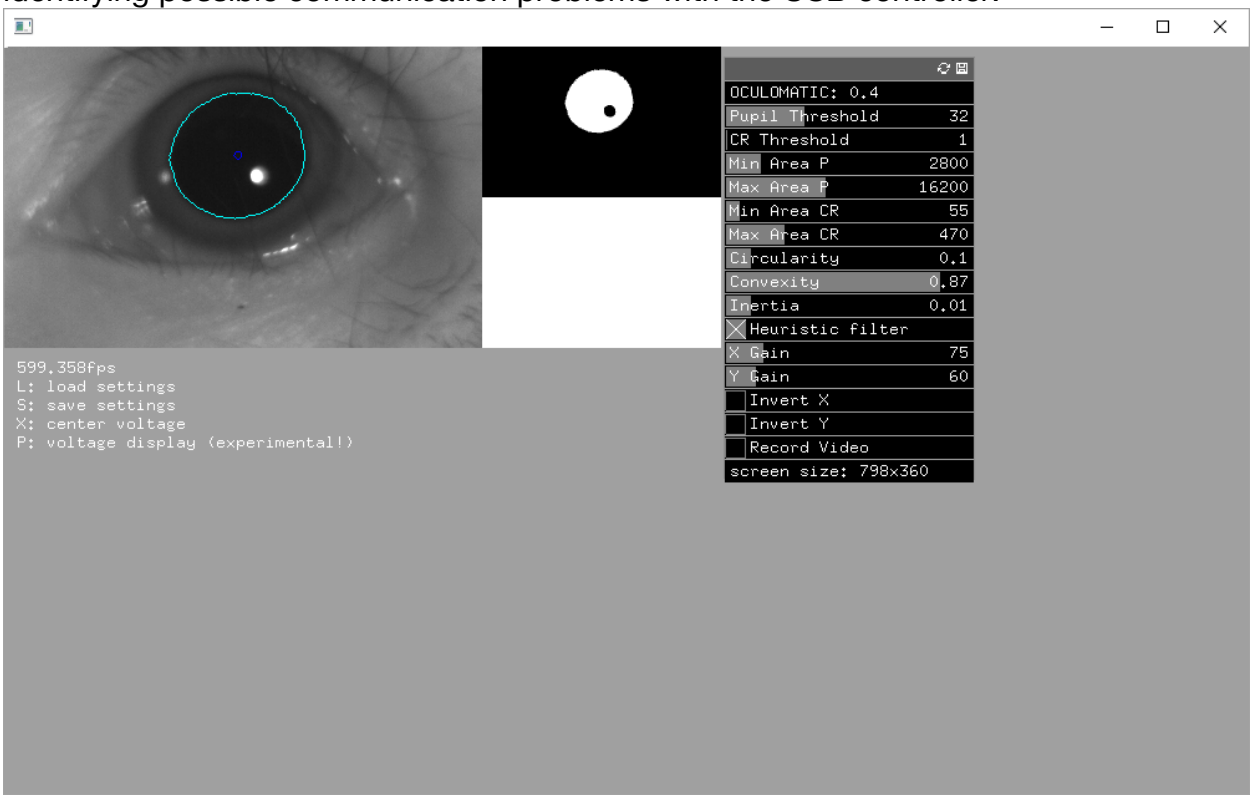

Figure 5. Oculomatic main user interface.

Press the L key on the keyboard to load the standard settings. Pressing the S key saves newly changed settings and overwrites the previous settings file. Setup usually takes no more than 30 seconds. Most settings should be kept constant between experiments and only play a role during initial setup. I have not had to change Circularity, Convexity or Inertia for any setup and believe these settings should just be kept at their default state (a future release will likely remove them and have those ranges hard coded).
Pupil threshold as well as Min and Max Area of the Pupil are the most important parameters. Make sure that the threshold is set correctly by verifying the thresholded image of the pupil shown to the right. Once you have confirmed that set a range for acceptable Pupil dimensions (Min and Max Area P) that works for your subject. Be sure to keep in mind the pupil diameter will change due to luminance changes of your stimulus display! Don't make this range too small and initially try what works best for you. When the cyan circle encloses the pupil, tracking started and analog outputs are sent.

Because the pupil mid point pixel location is arbitrary in regards to the analog output range of the national instrument cards it is essential to perform an initial mid point calibration. This requires the subject to fixate on a central fixation point while the experimenter presses the X key. Gain can be independently

altered for the horizontal and vertical position if needed. If the gain settings are altered a NEW midpoint has to be calibrated as to not introduce non linear shifts in transformation.

My usual approach is to keep the gain constant between experimental sessions and rather perform a 5 point calibration in my experimental control software.

5. Remarks